Chronic Conditions and Risk of In-Hospital Death

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Objective. This study examined the relationship of in-hospital death and 13 conditions likely to have been present prior to the patient's admission to the hospital, defined using secondary discharge diagnosis codes.
Data Sources and Study Setting. 1988 California computerized hospital discharge abstract data, including 24 secondary diagnosis coding slots, from all general, acute care hospitals.
Study Design. The odds ratio for in-hospital death associated with each of 13 chronic conditions was computed from a multivariable logistic regression using patient age and all chronic conditions to predict in-hospital death.
Data Extraction. All 1,949,276 general medical and surgical admissions of persons over 17 years of age were included. Patients were assigned to four groups according to the mortality rate of their reason for admission; some analyses separated medical and surgical hospitalizations.
Principal Findings. Overall mortality was 4.4 percent. For all cases, mortality varied by chronic condition, ranging from 5.3 percent for coronary artery disease to 18.6 percent for nutritional deficiencies. The odds ratios associated with the presence of a chronic condition were generally highest for patients in the rare mortality group. Although chronic conditions were more commonly listed for medical patients, the associated odds ratios were generally higher for surgical patients, particularly in lower mortality groups.
Conclusions. Studies examining death rates need to consider the influence of chronic conditions. Chronic conditions had a particularly significant association with the likelihood of death for admission types generally associated with low mortality rates and for surgical hospitalizations. The accuracy and completeness of discharge diagnoses require further study, especially relating to chronic illnesses.
Keywords. Chronic conditions, in-hospital death, discharge diagnoses

Health services researchers and health policymakers are increasingly examining short-term mortality rates as indicators of treatment effectiveness or quality of care (Dubois, Rogers, Moxley, et al. 1987; Dubois, Brook, and

Rogers, 1987; Sullivan and Wilensky 1991; Wilson, Smoley, and Werdegar 1993; Pennsylvania Health Care Cost Containment Council 1994). Meaningful interpretation of such figures, however, requires adjusting for patient risk of death prior to the intervention or hospitalization (Jencks, Daley, Draper, et al. 1988; Green et al. 1990; Green, Passman, and Wintfeld 1991; Park, Brook, Kosecoff, et al. 1990; Daley 1990; Iezzoni 1994). Efforts to predict which patients will die in the hospital often concentrate on acute clinical conditions or physiologic abnormalities (Brewster, Karlin, Hyde, et al. 1985; Wagner, Knaus, and Draper 1986; Daley, Jencks, Draper, et al. 1988; Keeler, Kahn, Draper, et al. 1990; Iezzoni et al. 1992; Knaus et al. 1993; Lemeshow, Teres, Klar, et al. 1993). This is clinically appropriate, given that acute derangements or organ failure inevitably precede imminent death. Despite this justifiable focus on acute risks, there are compelling arguments for also considering the impact of chronic illnesses, conditions that are pre-existing, often long-term, and generally palliated, not cured.

A first argument for considering chronic disease is epidemiological. Especially among older populations, acute illnesses typically arise in the context of pre-existing conditions, such as diabetes mellitus, chronic ischemic heart disease, peripheral vascular disease, and chronic obstructive pulmonary disease. A second argument is clinical: persons with a heavy burden of chronic ailments often are more susceptible to the effect of acute illnesses than other patients. For example, an otherwise healthy 60-year-old person with pneumonia is more likely to survive the infection than someone of

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This research was supported by the Agency for Health Care Policy and Research, under grant no. R01 HSO6512-02. The views expressed are solely those of the authors.

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equal age with severe, underlying chronic pulmonary disease. This concept of a "physiologic reserve," or the body's innate capacity to overcome acute illness, has led the developers of the Acute Physiology and Chronic Health Evaluation (APACHE) to include chronic disease and patient age in their model to predict risk of imminent death for patients hospitalized in intensive care units (Knaus et al. 1985; Knaus, Wagner, Draper, et al. 1991).

One final argument is pragmatic, relating to the data used to create risk predictions. Many health services and policy studies of mortality rely on administrative databases. In general, these are large, computer-readable data files created primarily for administrative purposes, such as billing or hospital rate setting (Connell, Diehr, and Hart 1987; Wennberg, Roos, Sola, et al. 1987; Roos, Roos, and Sharp 1987; Anderson, Steinberg, Whittle, et al. 1990; Roos et al. 1988; U.S. Congress, Office of Technology Assessment 1985). While these databases typically contain discharge diagnoses reflecting all conditions addressed during the hospital stay, they currently do not indicate whether a given diagnosis was present on admission or arose later in the hospitalization (Iezzoni 1990; Iezzoni, Daley, Heeren, et al. 1994).[1] Conditions appearing later in the stay could reflect complications of care or iatrogenic events, rather than risk factors intrinsic to the patient's prior clinical state. Including such conditions in a risk prediction model could confound efforts to make inferences about quality of care, for example, from risk-adjusted mortality data. To avoid including as risk factors those conditions that may have newly arisen during the hospital stay, one strategy is to focus exclusively on chronic conditions that certainly were present (although potentially undetected) prior to the patient's admission to the hospital.

Despite these arguments for looking at the impact of chronic conditions on imminent death, relatively little work has been performed in this field. One growing body of literature examines the impact of "comorbidities" (additional conditions not causally linked to the principal diagnosis; e.g., in a patient admitted for colon cancer, intestinal obstruction is a complication while hypertension is a comorbidity) on patient risk for a variety of outcomes (Greenfield et al. 1987; Greenfield et al. 1988; Charlson et al. 1987; Jencks, Williams, and Kay 1988; Iezzoni, Foley, Daley, et al., 1992; Greenfield et al. 1993). Comorbidities can be either acute or chronic. For example, a new myocardial infarction in an elderly person admitted for repair of a hip fracture is an example of an acute comorbidity. Much of the prior work on comorbidities has included both acute and chronic conditions. Again, however, because discharge abstracts do not indicate the timing of secondary diagnoses, we chose to focus on chronic illnesses. For example, one might feel differently about the acute myocardial infarction in the hip fracture patient if it was suspected on admission (i.e., if the patient was admitted following a fall potentially related to a myocardial event, the initial in-hospital evaluation would involve not only the fracture but also "ruling out" myocardial infarction), versus an infarction occurring postoperatively.

Given this background, our principal research questions were:

- Do chronic conditions increase the risk of in-hospital death?
- Does the impact of chronic conditions vary depending on the mortality rate associated with the principal condition or reason for patient admission to the hospital?
- Is the effect of chronic conditions on in-hospital death different for medical versus surgical admissions?

METHODS

DATABASES

We used the statewide computerized hospital discharge abstract data set from California for 1988, obtained from the California Office of Statewide Health Planning and Development (OSHPD). This database contains the discharge diagnosis codes, using *International Classification of Diseases, Ninth Revision, Clinical Modification* (U.S. Department of Health and Human Services 1989) or ICD-9-CM, assigned by California hospitals to each individual discharge during the year. The state requires these data for patients of all ages. The California data set offers two advantages: first, it permits the listing of up to 24 secondary diagnoses in addition to the principal diagnosis (for a total of 25 diagnoses); and second, the state is among the most active in the country in monitoring hospital diagnosis coding practices and encouraging complete and accurate coding. For example, while California hospitals are expected to follow standard ICD-9-CM coding guidelines promulgated through the American Hospital Association, the OSHPD circulates periodic newsletters (the *Discharge Data Review*) on particularly difficult coding topics. The state also performs occasional studies of hospital coding accuracy (Meux, Stith, and Zach 1990).

The computerized version of the 1988 complete American Hospital Association (AHA) annual hospital survey was used to identify hospital characteristics. We used both AHA and state information on hospital characteristics to eliminate long-term care and rehabilitation facilities; Department of Veterans Affairs hospitals; specialty hospitals (e.g., eye and ear infirmaries, children's hospitals); psychiatric hospitals; and substance abuse and detoxification facilities. We removed cases with pediatric diagnosis-related groups (DRGs), length of stay greater than 365 days, and "ungroupable" DRGs. We also eliminated cases for whom the following key data elements were missing or invalid: age, sex, discharge disposition (e.g., death), and principal diagnosis (none of the cases were missing principal diagnosis). This resulted in elimination of less than 0.001 percent of the cases. All remaining cases were grouped by the Health Care Financing Administration Version 7 DRG software (3M Health Information Systems 1990).

SELECTION AND GROUPING OF STUDY CASES

We included adult patients admitted for general medical or surgical conditions. These cases were essentially a residual category, following removal of all persons under age 18 and all persons in obstetrical, substance abuse, psychiatric, or rehabilitation DRGs, and all women with a diagnosis or procedure code indicating newborn delivery, regardless of their DRG. This resulted in a total of 1,949,276 cases.

One of our two major research questions was whether the impact of chronic conditions varied depending on the mortality rate associated with the principal condition or reason for patient admission to the hospital. For example, are chronic conditions more or less important for patients admitted for high-mortality disorders (e.g., end-stage liver failure) than for patients admitted for low-mortality reasons (e.g., knee surgery)? A second part of this question involved whether the impact of chronic conditions varied depending on whether the admission was medical or surgical. To answer these questions, we categorized patients into four distinct groups according to the mortality rate of their particular reason for admission. We also determined whether the admission was medical or surgical.

To sort patients into the four mortality groups, we first assigned them to "adjacent DRGs" (or ADRGs). ADRGs aggregate those DRGs split previously by the presence of complications or comorbidities (C.C.), age, or outcome.[2] ADRGs are often used by health services researchers wanting to disregard the C.C. splits of the DRG algorithm (such as Conklin and Houchens 1987; Fetter, Freeman, Park, et al. 1989; Thomas and Ashcraft 1991; and Iezzoni et al. 1992). We focused on ADRGs rather than DRGs because many of the 13 chronic condition codes are designated as C.C.s by the DRG algorithm.

It is important to note that the DRG classification scheme often is clinically heterogeneous. In addition, it was designed to predict resource consumption, not risk of death. Nevertheless, DRGs (and therefore the ADRGs) have the considerable advantage of being readily available, well known and documented, widely used, and easy to manipulate. DRGs reflect the reason for admission: DRG assignments start with separating patients by their "principal diagnoses" (the condition established after study to be chiefly responsible for causing admission of the patient to the hospital) into major diagnostic categories (MDCs), and then splitting further into medical versus surgical cases. DRGs are therefore a useful tool for differentiating surgical from medical admissions. Despite the clinical caveats, we thus viewed ADRGs as a reasonable method for initially grouping cases with similar risks of in-hospital death.

We assigned individual ADRGs to surgical and medical categories based on the designation of the DRG software. To group cases according to death rate related to the reason for admission, we examined this rate for each individual ADRG. ADRGs with death rates less than 1 percent comprised the rare mortality group; ADRGs with rates greater than 1 percent but less than 5 percent became the low mortality group; ADRGs with rates between 5 percent and 15 percent were the moderate mortality group; and ADRGs with rates over 15 percent were considered high mortality. Table 1 lists examples of medical and surgical ADRGs assigned to each of these mortality groups chosen to demonstrate a range of MDCs. A list of the complete ADRG assignments is available from the authors.

DESIGNATION OF CHRONIC CONDITIONS

Our goal was to identify conditions that were likely to have been present prior to patient admission to the hospital, albeit potentially not yet diagnosed. For example, admission to the hospital with seizure may be the first indication of brain metastases in a lung cancer patient, but the metastatic disease is nonetheless pre-existing; it did not arise *de novo* during the hospitalization. In specifying this list, we recognized that there are numerous chronic disorders, of different prevalence and potential impact on risk of death. For example, psoriasis is generally chronic but rarely of sufficient severity to increase risk of imminent death. Our aim was therefore to select 10 to 15 conditions that were either common or clinically judged to be important sources of risk of short-term mortality.

To identify candidate conditions, we extensively reviewed the literature on severity measures, comorbidity indexes, and surgical prognostic factors (Goldmann, Brown, Levy, et al. 1982; Jewell and Persson 1985; Savino and DelGuercio 1985; Schneider 1985; Goldman 1983; Detsky, Abrams, McLaughlin, et al. 1986; Goldman, Caldera, Nussbaum, et al. 1977). We also reviewed the entire ICD-9-CM codebook, using clinical judgment to identify chronic conditions that could affect risk of imminent death. Although the different articles identified many identical conditions as sources of patient risk, it was not always possible to translate some of these factors into ICD-9-CM codes. We were also concerned about the possibility of underreporting certain chronic conditions in our discharge abstract data (Jencks, Williams, and Kay 1988; Iezzoni et al. 1992). This led us to eliminate a few conditions from consideration, such as essential hypertension and prior myocardial infarction.

Table 1: Examples of Adjacent DRG Assignments to Mortality Groups

*ADRG Numbers and Descriptions**		*Numbers of Cases*	*Death Rate*
Rare Mortality			
Medical			
96–97	Bronchitis and asthma with or without C.C.s	52,649	0.9%
140	Angina pectoris	51,487	0.4
182–183	Esophagitis, gastroenteritis, and miscellaneous digestive disorders with or without C.C.s	64,238	0.8
243	Medical back problems	30,168	0.3
410	Chemotherapy	31,795	0.6
Surgical			
164–167	Appendectomy with or without complicated principal diagnosis, with or without C.C.s	20,658	0.1
221–222	Knee procedures with or without C.C.s	10,173	0.0
257–258	Total mastectomy for malignancy with or without C.C.s	12,584	0.1
336–337	Transurethral prostatectomy with or without C.C.s	27,220	0.3
197–198	Total cholecystectomy without common duct exploration, with or without C.C.s	33,754	0.5
Low Mortality			
Medical			
24–25	Seizure and headache with or without C.C.s	19,465	1.4
88	Chronic obstructive pulmonary disease	10,707	3.8
174–175	Gastrointestinal hemorrhage with or without C.C.s	29,703	4.4
294–295	Diabetes, age above and below 35 years	21,689	2.0
320–321	Kidney or urinary tract infections with or without C.C.s	28,533	3.0
Surgical			
5	Extracranial vascular procedures	6,919	1.2
112	Percutaneous cardiovascular procedures	21,585	1.1
152–153	Minor small and large bowel procedures with or without C.C.s	2,385	1.6
195–196	Total cholecystectomy with common duct exploration with or without C.C.s	5,266	1.2
210–211	Hip and femur procedures except major joint with or without C.C.s	18,379	2.4
Moderate Mortality			
Medical			
14	Specific cerebrovascular disorders except transient ischemic attack	42,095	14.2
121–123	Acute myocardial infarction with or without cardiovascular complication, patient discharged alive or expired	43,118	14.2
127	Heart failure and shock	60,672	7.5

Continued

Table 1: Continued

*ADRG Numbers and Descriptions**		*Numbers of Cases*	*Death Rate*
296–297	Nutritional and miscellaneous metabolic disorders with and without C.C.s	32,089	6.1
490	Human immunodeficiency virus with and without other related condition	1,444	6.8
Surgical			
1	Craniotomy except for trauma	10,737	11.5
106	Coronary bypass with cardiac catheterization	11,630	5.1
113	Amputation for circulatory sytem disease except upper limb/toe	3,494	8.9
148–149	Major small and large bowel procedures with and without C.C.s	25,215	5.5
154–155	Stomach, esophageal, and duodenal procedures with and without C.C.s	12,117	7.4
High Mortality			
Medical			
27	Traumatic stupor and/or coma with coma greater than 1 hour	1,684	25.1
82	Respiratory neoplasms	12,181	28.0
172–173	Digestive malignancy with and without C.C.s	5,507	24.7
403–404	Lymphoma and/or nonacute leukemia with or without C.C.s	5,540	19.1
416	Septicemia	14,638	21.1
Surgical			
472	Extensive burns with operating room procedure	189	25.9
481	Bone marrow transplant	204	19.6
480	Liver transplant	129	15.5
483	Tracheostomy except for mouth, larynx, pharynx disorders	5,985	39.6
484	Craniotomy for multiple significant trauma	419	33.4

*C.C. = complication or comorbidity.

Candidate conditions, defined by groups of ICD-9-CM codes, were refined after looking at secondary diagnoses from comparable California discharge abstract data from the prior year, 1987. This resulted in a few modifications. Because the separate category created for leukemia and lymphoma included very small numbers of cases, it was combined with "cancer with poor prognosis." A category created for "ventilator dependence" using ICD-9-CM V codes was eliminated due to small numbers. Mortality rates for each individual ICD-9-CM code were examined within each chronic condition. ICD-9-CM codes were eliminated if (1) they never or very rarely occurred (recalling that the database included thousands of cases); or (2) the mortality rate of an individual ICD-9-CM code was very different from that for the condition overall. The number of cases within individual ICD-9-CM codes was often very small. Examination of mortality at the diagnosis code level was, therefore, qualitative, and largely involved clinical judgment about the specific meaning of the code as defined in the ICD-9-CM codebook.

Table 2 shows the 13 "chronic conditions" in the final list. Several comments about this list are important. First, not all conditions on this list are single disease entities (i.e., requiring clear specification of a single etiology and pathophysiology). Some, such as nutritional deficiencies, severe chronic liver disease, and dementia, could have a wide variety of root causes. A number of the conditions, such as congestive heart failure and nutritional deficiencies, could be pre-existing but also could newly arise during the hospital stay. However, we believed that in most instances the condition, or the strong predisposition to the condition, would be pre-existing. For instance, patients who have congestive heart failure are likely either to have had the condition before or to have had predisposing underlying cardiac disease. Finally, the category "functional impairment" encompasses a range of conditions that reflect patient debility regardless of the cause (e.g., hemiplegia, quadriplegia, gastrostomy, wheelchair use). These are generally physical functional indicators that may provide important clues about patients' physiologic reserve.

Table 2: List of Chronic Conditions

1. Cancer (primary) with poor prognosis*
2. Metastatic cancer
3. Acquired immunodeficiency syndrome (AIDS)
4. Chronic pulmonary disease
5. Coronary artery disease
6. Congestive heart failure
7. Peripheral vascular disease
8. Severe chronic liver disease
9. Diabetes mellitus with end organ damage†
10. Chronic renal failure
11. Nutritional deficiencies
12. Dementia
13. Functional impairment‡

*Includes leukemias, lymphomas, and malignancies of the following organs: esophagus, stomach, liver, pancreas, lung, pleura, ovary and uterine adnexa, and brain.

†Includes the following manifestations of diabetes mellitus: renal, neurological, peripheral vascular, ophthalmic, and other specified and unspecified complications.

‡Includes late effects of cerebrovascular disease, hemiplegia, quadriplegia, unspecified paralysis, tracheostomy, gastrostomy, wheelchair dependence, and unspecified machine dependence.

Chronic conditions were deemed present only if they were among the secondary diagnoses (i.e., a chronic condition could not be the principal diagnosis or reason for admission). The ICD-9-CM codes that define the chronic conditions are available upon request from the authors.

OUTCOME VARIABLE

Many current studies of short-term deaths examine mortality 30 days following hospital admission, using the ability of the Medicare data files to track patient mortality over time. (Sullivan and Wilensky 1991; Jencks, Daley, Draper, et al. 1988; Keeler, Kahn, Draper, et al. 1990; Wennberg, Roos, Sola, et al. 1987; Iezzoni et al. 1991). This approach holds constant the window of observation at 30 days and, thus, avoids difficulties in comparing mortality rates across hospitals caused by differences in hospital discharge practices (Jencks, Williams, and Kay 1988). However, the 1988 California database did not permit identification of out-of-hospital deaths; therefore, our outcome variable was in-hospital death. Given that the goal of our study was to examine differences in likelihood of death related to the presence of given secondary diagnoses at the individual case level (i.e., rather than at the hospital level), the issue of differences in hospital discharge practices becomes less pressing.

ANALYSES

We performed logistic regressions to predict in-hospital death using the 13 chronic conditions and patient age as the independent, predictor variables. Age was entered into the logistic regression as categorical variables as follows: 18 through 44; 45 through 64; 65 through 74; 75 through 84; and 85 years of age or older. Separate regressions were performed for all patients, for medical patients, and for surgical patients; for each set of patients (all, medical, and surgical), separate regressions were also performed within each of the four death rate categories. The odds ratio for in-hospital death associated with each chronic condition was taken from these multivariable regressions. Because of the large number of cases, many of the findings are statistically significant, even when close to 1.00.

RESULTS

Across all cases, 37.4 percent of patients had at least one chronic condition and 10.9 percent had two or more (Table 3). The fraction of patients with one or more chronic condition(s) increased across the four mortality categories, from 24.9 percent for all cases in rare-mortality conditions to 62.0 percent in the high-mortality group. In general, medical patients had more chronic conditions listed than did surgical patients.

Table 4 lists the percentage of all patients who died by chronic condition as well as the percent of patients with each specific chronic condition, regardless of whether they had any other chronic condition. Table 5 indicates, for all cases, the odds ratio for in-hospital death associated with each chronic condition from the multivariable logistic regressions. Tables 6 and 7 show comparable information for medical cases, and Tables 8 and 9 display comparable data for surgical cases.

The database contained 1,949,276 cases, with 46.6 percent falling in the rare-mortality group and 5.8 percent in the high-mortality group. Surgical cases were more likely to be in the rare-mortality group: 58.3 percent of surgical cases, compared to 39.4 percent of medical cases. In contrast, a larger fraction of medical cases were in the high-mortality group: 8.6 percent of medical cases, compared to 1.1 percent of surgical cases. Overall mortality was 4.4 percent, with 5.5 percent for medical cases and 2.5 percent for surgical cases. However, in the high-mortality group, 34.4 percent of surgical patients died compared to 24.3 percent of medical cases.

For all cases, mortality varied by chronic condition, ranging from 5.3 percent for coronary artery disease to 18.6 percent for nutritional deficiencies (Table 4). The lowest death rates were associated with coronary artery disease (rare-, low-, and moderate-mortality groups) and dementia (high-

Table 3: Percent of Cases by Number of Chronic Conditions

	Number of Chronic Conditions			
Case Types	*0*	*1*	*2*	*3+*
All Cases	62.6	26.5	8.6	2.3
Rare mortality	75.1	18.8	5.0	1.1
Low mortality	61.0	28.3	8.5	2.2
Moderate mortality	44.6	36.9	14.2	4.3
High mortality	38.0	39.4	16.8	5.8
Medical Cases	55.6	30.9	10.6	2.9
Rare mortality	62.9	27.4	8.0	1.7
Low mortality	64.0	25.8	8.1	2.1
Moderate mortality	41.7	38.6	15.2	4.5
High mortality	37.1	40.1	17.0	5.8
Surgical Cases	74.0	19.2	5.3	1.5
Rare mortality	88.8	9.3	1.6	0.3
Low mortality	55.1	33.1	9.2	2.6
Moderate mortality	51.5	33.0	11.7	3.8
High mortality	49.3	31.2	14.2	5.3

Table 4: Percent of Cases Dying In-Hospital by Chronic Condition and Percent with the Condition (All Case Types)

	Mortality Group Percent of Cases Dying (Percent with the Chronic Condition)				
Chronic Condition	*Rare Mortality* n = *769,337*	*Low Mortality* n = *892,770*	*Moderate Mortality* n = *214,635*	*High Mortality* n = *72,534*	*All Cases* n = *1,949,276*
Cancer with a poor prognosis	1.0% (1.9%)	13.1% (1.9%)	25.4% (2.5%)	32.9% (4.8%)	12.1% (2.0%)
Metastatic cancer	1.2 (2.8)	10.6 (4.2)	24.4 (4.3)	35.2 (24.6)	14.8 (4.4)
Acquired immunodeficiency syndrome	2.2 (0.1)	7.4 (0.4)	15.2 (3.7)	45.7 (0.3)	13.0 (0.6)
Chronic pulmonary disease	0.8 (3.8)	4.8 (13.5)	14.6 (12.2)	30.6 (16.2)	7.1 (9.6)
Coronary artery disease	0.5 (7.6)	4.3 (16.8)	13.1 (16.6)	31.1 (8.6)	5.3 (12.9)
Congestive heart failure	2.9 (1.4)	10.0 (6.9)	22.5 (12.6)	38.9 (11.0)	14.6 (5.5)
Peripheral vascular disease	0.7 (1.2)	6.1 (3.4)	14.2 (4.3)	36.2 (2.0)	7.4 (2.6)
Severe chronic liver disease	3.0 (0.2)	9.7 (1.0)	21.7 (2.5)	41.9 (1.3)	14.9 (0.8)
Diabetes with end organ damage	0.9 (1.3)	4.1 (4.7)	15.3 (5.0)	29.3 (3.6)	6.5 (3.3)
Chronic renal failure	2.4 (0.5)	7.0 (3.4)	19.1 (3.2)	39.8 (2.5)	9.9 (2.2)
Nutritional deficiencies	3.8 (0.2)	13.2 (1.5)	23.7 (2.1)	39.2 (4.9)	18.6 (1.2)
Dementia	1.2 (0.5)	7.1 (2.1)	15.2 (2.5)	27.0 (2.2)	9.0 (1.5)
Functional impairment	0.8 (1.8)	6.2 (3.6)	12.8 (10.7)	29.4 (5.3)	8.5 (3.7)
All cases*	0.2	3.6	13.8	29.7	4.4

*Percent in-hospital deaths regardless of chronic condition.

mortality group). Chronic conditions associated with the highest mortality included nutritional deficiencies for the rare- and low-mortality group, cancer with poor prognosis for the moderate group, and severe chronic liver disease for the high-mortality group.

For the high-mortality group, surgical cases had higher death rates than medical cases associated with all 13 chronic conditions. In comparison, for the rare-mortality group, surgical patients had higher death rates for 12 chronic diseases; in the low-mortality group, surgical cases had higher death rates for 5 of the 13 chronic conditions; and for the moderate-mortality group, surgical cases had higher death rates for eight chronic conditions. However, as noted earlier, surgical cases generally were less likely to have chronic conditions coded than medical cases. For example, in the rare-mortality group, all 13 chronic conditions were more frequently coded in medical rather than in surgical cases.

Across all cases, all chronic conditions except coronary artery disease significantly increased the odds ratio for in-hospital death for the rare- and

Table 5: Odds Ratio for In-Hospital Death by Chronic Condition Following Adjustment for Patient Age and Other Chronic Conditions (All Case Types)

	Mortality Group				
Chronic Condition	*Rare Mortality* n = *907,736*	*Low Mortality* n = *490,715*	*Moderate Mortality* n = *438,617*	*High Mortality* n = *112,208*	*All Cases* n = *1,949,276*
Cancer with a poor prognosis	2.25	2.82	2.17	1.28	1.84
Metastatic cancer	4.03	3.69	1.83	1.88	3.93
Acquired immunodeficiency syndrome	18.85	11.12	3.48	2.35	9.86
Chronic pulmonary disease	1.86	1.36	0.90	0.86	1.27
Coronary artery disease	1.02*	0.90	0.85	0.87	0.86
Congestive heart failure	4.80	3.20	2.16	1.51	2.99
Peripheral vascular disease	1.43	1.38	1.17	1.18***	1.21
Severe chronic liver disease	7.69	3.85	2.95	1.94	4.52
Diabetes with end organ damage	1.68	1.35	1.03*	0.93**	1.29
Chronic renal failure	3.89	2.33	1.54	1.24	2.14
Nutritional deficiencies	5.66	3.27	1.82	1.50	3.05
Dementia	1.26**	1.17***	0.77	0.68	1.02*
Functional impairment	2.11	1.57	1.13	0.91***	1.54

All odds ratios were significant at the $p = .000$ level except those marked as follows:
*Not significant: $p > .05$; **$.01 < p \leq .05$; ***$.000 < p \leq .01$.

low-mortality groups, in comparison to nine chronic conditions for the moderate- and eight for the high-mortality groups (Table 5). The odds ratios associated with the presence of a chronic condition were highest for patients in the rare-mortality group for 12 chronic conditions (all except cancer with poor prognosis). In contrast, the odds ratios associated with ten chronic conditions were lowest for the high-mortality group; for the other three, odds ratios were lowest in the moderate-mortality group. Across all cases, AIDS resulted in the highest relative odds of in-hospital death. Metastatic cancer, congestive heart failure, severe chronic liver disease, and nutritional deficiencies also had comparatively high odds ratios across all cases.

In medical cases, 11 of the 13 chronic conditions had odds ratios significantly higher than one for the rare-mortality group compared to eight of the chronic conditions in the high-mortality group (Table 7). For all 11 chronic conditions that significantly increased the odds ratios, the highest ratios were either in the rare- or low-mortality groups. For 12 of the chronic conditions, the lowest odds ratios were for the high-mortality group.

Table 6: Percent of Cases Dying In-Hospital by Chronic Condition and Percent with the Condition (Medical Cases)

	Mortality Group *Percent of Cases Dying (Percent with the Chronic Condition)*									
	Rare Mortality		*Low Mortality*		*Moderate Mortality*		*High Mortality*		*All Cases*	
Chronic Condition	n = *369,159*		n = *628,780*		n = *158,759*		n = *65,805*		n = *1,222,503*	
Cancer with a poor prognosis	0.9%	(3.7%)	13.4%	(2.1%)	27.5%	(2.7%)	32.1%	(5.1%)	12.0%	(2.8%)
Metastatic cancer	1.1	(4.3)	14.2	(2.8)	28.4	(4.0)	35.0	(26.6)	18.4	(4.7)
Acquired immunodeficiency syndrome	1.8	(0.1)	6.7	(0.5)	15.1	(4.4)	40.9	(0.3)	12.6	(0.9)
Chronic pulmonary disease	0.7	(5.0)	4.6	(15.4)	14.6	(13.5)	28.1	(15.5)	7.2	(12.0)
Coronary artery disease	0.4	(12.7)	4.6	(15.5)	12.7	(18.5)	28.8	(8.6)	5.6	(14.7)
Congestive heart failure	2.2	(2.3)	9.1	(7.5)	22.2	(14.2)	36.1	(10.4)	14.1	(7.0)
Peripheral vascular disease	0.6	(1.7)	6.5	(2.9)	16.5	(3.4)	34.1	(1.9)	8.2	(2.6)
Severe chronic liver disease	2.6	(0.1)	8.0	(1.1)	20.5	(2.4)	41.5	(1.2)	14.0	(1.0)
Diabetes with end organ damage	0.8	(1.8)	3.9	(4.9)	16.0	(4.7)	26.2	(3.5)	6.5	(3.9)
Chronic renal failure	1.8	(0.8)	7.3	(3.1)	20.3	(2.4)	37.0	(2.5)	10.3	(2.3)
Nutritional deficiencies	3.1	(0.3)	12.2	(1.7)	23.4	(2.2)	38.3	(4.7)	18.2	(1.5)
Dementia	0.9	(0.8)	7.4	(2.6)	15.6	(3.0)	26.6	(2.3)	9.4	(2.0)
Functional impairment	0.8	(3.0)	6.1	(3.9)	12.8	(12.7)	29.1	(4.6)	8.6	(4.8)
All cases*	0.3		3.8		14.5		28.8		5.4	

*Percent in-hospital death regardless of chronic condition.

For surgical patients, the odds ratios were highest in the rare-mortality group for all 13 chronic conditions (Table 9). Even for coronary artery disease, surgical patients in the rare-mortality group had an odds ratio of 1.32 (95 percent C.I. = 1.10, 1.60). For surgical patients in the rare-mortality group, some chronic conditions were associated with very large odds ratios, such as: 35.55 (95 percent C.I. = 12.12, 92.92) for AIDS; 11.15 (95 percent C.I. = 7.94, 15.66) for severe chronic liver disease; and 8.58 (95 percent C.I. = 5.96, 12.34) for nutritional deficiencies.

The odds ratios for in-hospital death associated with chronic conditions were generally higher for surgical patients than for medical patients, particularly in lower- mortality groups. For patients in the rare-mortality group, all 13 chronic conditions had a higher odds ratio in surgical rather than medical patients. In comparison, for patients in the high-mortality group, the odds ratios for surgical patients were higher than those for medical patients for 8 of the 13 chronic conditions.

Table 7: Odds Ratio for In-Hospital Death by Chronic Condition Following Adjustment for Patient Age and Other Chronic Conditions (Medical Cases)

	Mortality Group				
Chronic Condition	*Rare Mortality* n = *478,835*	*Low Mortality* n = *322,119*	*Moderate Mortality* n = *309,250*	*High Mortality* n = *103,867*	*All Cases* n = *1,214,071*
Cancer with a poor prognosis	1.84	2.63	2.04	1.31	1.43
Metastatic cancer	3.52	3.96	2.53	1.99	4.45
Acquired immunodeficiency syndrome	14.06	10.96	3.44	2.17	7.79
Chronic pulmonary disease	1.79	1.39	0.83	0.82	1.13
Coronary artery disease	0.91**	0.92**	0.84	0.85	0.78
Congestive heart failure	4.11	2.85	2.02	1.46	2.52
Peripheral vascular disease	1.34***	1.44	1.19	1.17***	1.17
Severe chronic liver disease	5.79	3.60	2.66	2.22	3.64
Diabetes with end organ damage	1.47	1.30	0.97*	0.88***	1.16
Chronic renal failure	3.12	2.48	1.38	1.20	1.91
Nutritional deficiencies	4.94	2.90	1.63	1.48	2.60
Dementia	1.03*	1.16**	0.79	0.71	0.97*
Functional impairment	1.81	1.48	1.07***	0.94	1.37

All odds ratios were significant at the $p = .000$ level except those marked as follows:
*Not significant: $p > .05$; **$.01 < p \leq .05$; ***$.000 < p \leq .01$.

DISCUSSION

Using computerized discharge abstract data, we found that chronic conditions significantly increased the likelihood of in-hospital death for patients admitted for reasons generally associated with very low mortality. For high-mortality admissions, some chronic conditions significantly increased the risk of death, while others had little or no effect. In terms of increasing the chance of in-hospital mortality, therefore, chronic conditions were more important for patients admitted for low-mortality than for high-mortality causes. Although chronic conditions were more common (or at least more commonly coded) among medical patients, the associated odds ratios were generally higher for surgical patients.

Some of the chronic conditions, however, had odds ratios significantly higher than one regardless of the mortality associated with the reason for

Table 8: Percent of Cases Dying In-Hospital by Chronic Condition and Percent with the Condition (Surgical Cases)

	Mortality Group Percent of Cases Dying (Percent with the Chronic Condition)									
Chronic Condition	*Rare Mortality* n = *400,178*		*Low Mortality* n = *263,990*		*Moderate Mortality* n = *43,865*		*High Mortality* n = *6,729*		*All Cases* n = *714,762*	
Cancer with a poor prognosis	3.9%	(0.2%)	11.8%	(1.2%)	15.8%	(1.8%)	56.5%	(1.7%)	12.4%	(0.7%)
Metastatic cancer	1.2	(1.4)	7.4	(7.5)	13.8	(4.5)	48.5	(4.5)	7.0	(3.9)
Acquired immunodeficiency syndrome	2.9	(0.0)	13.6	(0.1)	15.5	(2.2)	66.7	(0.6)	15.2	(0.2)
Chronic pulmonary disease	0.9	(2.8)	5.3	(9.0)	13.2	(8.3)	47.8	(22.2)	6.4	(5.6)
Coronary artery disease	0.8	(2.9)	3.6	(20.1)	14.7	(11.6)	52.2	(9.0)	4.4	(9.8)
Congestive heart failure	5.4	(0.6)	12.7	(5.6)	23.9	(8.1)	55.9	(16.7)	16.0	(3.0)
Peripheral vascular disease	1.1	(0.7)	5.3	(4.4)	10.0	(7.9)	53.6	(2.3)	6.0	(2.5)
Severe chronic liver disease	3.2	(0.2)	15.8	(0.7)	25.0	(2.6)	44.3	(2.1)	16.8	(0.6)
Diabetes with end organ damage	1.2	(0.8)	4.7	(4.2)	13.1	(6.0)	55.1	(4.1)	6.2	(2.4)
Chronic renal failure	4.0	(0.3)	6.3	(4.0)	17.2	(5.2)	62.2	(3.0)	8.7	(2.0)
Nutritional deficiencies	6.2	(0.1)	16.3	(1.2)	25.9	(1.8)	45.2	(7.0)	20.0	(0.6)
Dementia	2.5	(0.2)	5.6	(1.2)	11.7	(1.2)	37.7	(0.9)	6.2	(0.6)
Functional impairment	1.0	(0.7)	6.7	(2.9)	11.5	(5.2)	30.3	(11.5)	7.6	(1.9)
All cases*	0.2		3.4		12.2		38.4		2.4	

*Percent in-hospital death regardless of chronic condition.

admission. Across all cases, cancer with poor prognosis, metastatic cancer, AIDS, congestive heart failure, peripheral vascular disease, severe chronic liver disease, chronic renal failure, and nutritional deficiencies always increased the odds ratios. Despite this, even for these chronic conditions, the magnitude of the odds associated with the rare-mortality group was much higher than that in the high-mortality group.

It is important to note that even though the increased odds of death are most striking among patients admitted in the rare-mortality group, the increase in the *actual* number of deaths associated with chronic conditions among these patients is small. It usually exceeds the baseline rate severalfold, resulting in higher relative odds than among high-mortality conditions. But because the mortality rate is so low (0.4 percent), this results in relatively few "extra" deaths. In contrast, the greatest increases in *absolute risk* associated with chronic conditions appear among the high- mortality group. Across all cases, although the high- mortality group contained only 5.8 percent of the patients, it accounted for about 32 percent of the deaths.

Table 9: Odds Ratio for In-Hospital Death by Chronic Condition Following Adjustment for Patient Age and Other Chronic Conditions (Surgical Cases)

	Mortality Group				
Chronic Condition	*Rare Mortality* n = *428,901*	*Low Mortality* n = *168,596*	*Moderate Mortality* n = *129,367*	*High Mortality* n = *8,341*	*All Cases* n = *735,205*
Cancer with a poor prognosis	6.32	2.82	1.90	1.67***	3.18
Metastatic cancer	4.74	3.42	1.30	1.17*	2.61
Acquired immunodeficiency syndrome	33.55	11.51	3.81	7.18	16.15
Chronic pulmonary disease	1.70	1.29	1.16	1.22***	1.66
Coronary artery disease	1.32***	0.87***	0.87	1.12*	1.08
Congestive heart failure	7.50	4.04	2.57	1.69	4.78
Peripheral vascular disease	1.64***	1.34	1.12**	1.29*	1.36
Severe chronic liver disease	11.15	4.58	3.74	0.88*	7.41
Diabetes with end organ damage	2.22	1.44	1.18***	1.48***	1.59
Chronic renal failure	7.00	2.20	1.86	2.26	2.75
Nutritional deficiencies	8.58	4.27	2.22	1.15*	4.59
Dementia	1.94***	1.13*	0.67	0.64**	0.94*
Functional impairment	3.01	1.75	1.33	0.58	1.92

All odds ratios were significant at the $p = .000$ level except those marked as follows:
*Not significant: $p > .05$; **$.01 < p \leq .05$; ***$.000 < p \leq .01$.

The generally higher odds ratios associated with chronic conditions for surgical compared to medical patients may relate to initial selection of patients for surgery. In general, surgeons do not operate on patients with a heavy burden of severe chronic disease (especially serious cardiac, pulmonary, renal, and hepatic illness) because of the attendant high risk of mortality and complications. Therefore, in most instances, patients who are operated upon have passed this initial clinical risk screen. Given the immediate and inherent risks of anesthesia and the inevitable physiologic derangements of major surgery in particular, chronic conditions may have a higher "marginal" impact on surgical than on medical patients.

As noted earlier, the clinical literature provides little information about the risk of death associated with chronic conditions stratified by mortality rates linked to the reason for admission. The experience in developing APACHE III, a severity measure specifically for critically ill patients admitted to intensive care units, supports our finding for the high-mortality group (Knaus, Wagner, Draper et al. 1991). The APACHE III investigators explored the potential impact of 34 "candidate chronic health items," defined generally by presence of organ failure, on the risk of in-hospital death. They found that the majority of the candidate conditions had little effect on predicting in-hospital mortality for these gravely ill patients. APACHE III assigns severity points for only seven chronic illnesses (listed in order of decreasing number of points: AIDS, hepatic failure, lymphoma, metastatic cancer, leukemia/multiple myeloma, immunosuppression, and cirrhosis).

Another study used 1983 discharge abstract data from California to examine the effect of "pre-existing conditions" on in-hospital mortality for patients admitted for trauma (Morris, MacKenzie, and Edelstein 1990). Five pre-existing conditions significantly increased the relative odds of death: chronic obstructive pulmonary disease, ischemic heart disease, diabetes mellitus, cirrhosis, and congenital coagulopathy. The authors noted, "Surprisingly, the increase in mortality that resulted from the presence of a [pre-existing condition] was generally greater among patients with less severe injuries" (p. 1,944). In contrast, pre-existing conditions appeared to have a negligible effect on mortality risk for patients with severe injuries who were over 64 years of age, and a modest effect on severely injured younger patients.

One possibility that must be considered for the finding relating to the high-mortality group is the well-known potential for coding bias–patients who are severely ill and in the process of dying have more severe acute conditions or complications that take precedence in coding over chronic diseases (Jencks, Williams, and Kay 1988; Iezzoni et al. 1992). Others have used administrative data to examine comorbid illness (Deyo, Cherkin, and Ciol 1992; Charlson 1993; Deyo 1993; Romano, Roos, and Jollis 1993a,b), but little work is available that looks at whether administrative data truly reflect the burden of chronic disease. Our study also cannot explicitly address this concern. However, it is interesting to note that even though we sorted patients into mortality groups using ADRGs (i.e., specifically ignoring C.C.s), the percent of cases with chronic conditions coded was highest for the high-mortality group for 6 of the 13 conditions and for the moderate-mortality group for 7 of them (Table 4). Although patients in the moderate- and high-mortality groups clearly had serious reasons for admission, chronic conditions were coded more frequently for them than for other patients. In addition, patients in the highest-mortality group were more likely than other patients to have more than one chronic condition listed (Table 3).

Nevertheless, questions remain about how completely chronic conditions are recorded, even though these conditions may affect patients and their care during hospitalizations. The California Office of Statewide Health

Planning and Development found secondary diagnoses underreported by hospitals (Meux, Stith, and Zach 1990). This study involved the reabstraction of 2,579 records from 1988 discharges from 30 randomly selected hospitals across a variety of conditions (excluding obstetrics, newborn, psychiatric, chemical dependency, and rehabilitation conditions). In 576 records, the reabstractor coded more secondary diagnoses than in the original hospital list. Secondary diagnoses that were underreported by the hospitals included chronic respiratory conditions (e.g., emphysema, chronic obstructive pulmonary disease, 7.6 percent of underreported conditions), stroke residuals (e.g., hemiplegia, dysphagia, 5.9 percent), arteriosclerotic heart disease (6.1 percent), and diabetes mellitus (3.6 percent). Romano and Mark (1994) reanalyzed these data to look at whether coding of comorbid illness was sensitive to the number of coding spaces. They found that when data from all 25 diagnosis coding slots were used, "comorbidity reporting was equally sensitive among deaths as among survivors" (Romano and Mark 1994, p. 88). In our study, all 24 secondary diagnosis positions were examined to identify chronic conditions.

We specifically eliminated essential hypertension and a single code of prior myocardial infarction from our list of chronic conditions because of suspected underreporting, although other studies have shown them to be related to increased mortality even in the short term. For example, one prospective clinical study found that a history of hypertension was significantly related to higher odds of inhospital mortality following noncardiac surgery (Browner, Li, Mangano, et al. 1992), and another clinical investigation found that a history of hypertension was associated with increased risk of postoperative myocardial ischemia in patients undergoing noncardiac surgery (Hollenberg, Mangano, Browner, et al. 1992). However, two studies relying exclusively on administrative data have found that essential hypertension significantly *decreases* the risk of in-hospital mortality (Jencks, Williams, and Kay 1988; Iezzoni et al. 1992). The leading explanation for these counterintuitive findings was a bias against coding essential hypertension among patients who died and, hence, had many acute and pressing clinical concerns that required coding.

Despite this possibility of coding bias, it is important to observe that all 13 chronic conditions did increase the relative odds of death, at least for some patients. Nonetheless, the potential for systematic underreporting of chronic conditions for patients who die in-hospital requires additional investigation.

Our study has important limitations. First, although we believe that our designated "chronic conditions" (or a strong predisposition for the chronic condition) were present prior to admission, this might not always have been true. Among our chronic conditions, we may have captured disorders (e.g., nutritional deficiencies) that occurred during the hospitalization and may relate to a variety of factors, including the quality of care. Second, our findings are subject to the questions often raised about the quality of administrative data, most notably coding accuracy and completeness (Fisher, Whaley, Krushat et al. 1992; Jencks 1992; Hsia, Krushat, Fagan, et al. 1988; Lloyd and Rissing 1985; Simborg 1981; Steinwald and Dummit 1989; Romano and Luft 1992; Hsia, Ahern, Ritchie, et al. 1992). Third, we relied on the ADRGs to distinguish medical from surgical cases and to stratify broadly by rate of in-hospital death. While the ADRGs are well suited to separating surgical from other cases, their use to define mortality strata may raise questions, especially given that DRGs were designed to predict resource consumption, not risk of in-hospital death. However, it is important to note that ADRGs were used only to group cases into broad categories by surgical status and mortality rate: all modeling of risk of death related to the presence of chronic conditions was performed within these strata, and ADRGs themselves were not included in the models.

Fourth, because the database did not permit the tracking of patients across hospitalizations, the ability to capture information on pre-existing conditions from prior hospitalizations was precluded. One study found that adding comorbidity information from admissions in the six months prior to an index hospitalization added significantly to the ability to predict risk for short-term mortality and readmissions (Roos et al. 1989). Finally, given the intrinsic limitations of ICD-9-CM and lack of clinical definitions (McMahon and Smits 1986; Mullin 1985), we cannot be sure of the exact clinical meaning of our "chronic conditions," as coded in the discharge abstract data (e.g., what levels of blood urea nitrogen and creatinine defined chronic renal failure).

Despite these limitations, our findings suggest that computerized discharge abstract data studies examining death rates need to consider the influence of chronic conditions. This is especially so for studies of admission types generally associated with low risk of death. The impact of chronic conditions on risk of in-hospital death is less striking for admission types with generally high mortality but, even among these patients, some chronic conditions significantly increase the odds of in-hospital death. Thus, while acute physiologic derangements are clinically obvious predictors of poor patient outcomes, chronic conditions also play an important role.

ACKNOWLEDGMENTS

We gratefully acknowledge the clinical advice of Charles Duncan, M.D., and Elliott S. Fisher, M.D., M.P.H., in specifying the chronic conditions.

NOTES

1. In June 1990, the National Committee on Vital and Health Statistics (NCVHS) recommended to the secretary of the Department of Health and Human Services that a comprehensive review of the Uniform Hospital Discharge Data Set (UHDDS, the prototype of most hospital discharge abstracts) be undertaken, in conjunction with the National Uniform Billing Committee, which oversees UB-82 and 92. From 1990 through early 1992, the Subcommittee on Ambulatory and Health Care Statistics conducted this examination. It submitted a proposal for revising the UHDDS in June 1992, including several important proposed changes. Importantly, the subcommittee recommended that a new data element be added to UHDDS–an "alpha" qualifier indicating whether the onset of the diagnosis preceded or followed admission to the hospital. This proposal was based on prior experience at the Mayo Clinic and in New York state, and it was acknowledged to add a "modest additional cost" to data collection. If this proposal is accepted, it is not clear when the change will go into effect.
2. An example of DRGs defined by outcome involves acute myocardial infarction, where the three DRGs pertaining to this diagnosis (121–123) are separated based on complicated cardiovascular conditions (121 and 122) and whether the patient died in-hospital (123). Patients discharged alive are grouped in DRGs 121 or 122, while all of those who die fall into DRG 123.

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